

Remote GPIB Control Using a GPIB-232CT-A

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Introduction

With the National Instruments GPIB-232CT-A, any computer with an RS-232 serial port can be a GPIB Talker/Listener/Controller. For standard local operations, the serial port of the GPIB-232CT-A is connected to the serial port of the computer. However, if a pair of modems were inserted between the serial port of the computer and the serial port of the GPIB-232CT-A, existing modem communication technology could be used to achieve remote GPIB control. Figure 1 shows the block diagram of such a system.

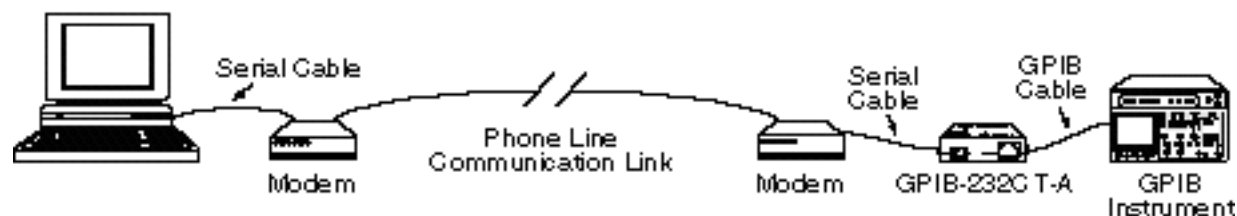


Figure 1. Typical Block Diagram of Remote GPIB Control with GPIB-232CT-A

An example of such an application is controlling a field test site from an office located in a city. The test site is a remote station, at which a spectrum analyzer is used to make measurements at a certain time each day. Rather than having to travel to the remote station each day, modems and the GPIB-232CT-A could be used to interface an application program, located on a computer in the office, with the spectrum analyzer in the field. The advantage of using a GPIB-232CT-A is that a second computer is not needed at the field site; and if several test sites were developed, this could prove to be cost-effective.

Modem Connections

The first step in the development of this application is to establish known modem connections. The user should set up a local modem connected to the computer with the application program and a remote modem connected to the GPIB-232CT-A. Although the remote modem must be an external model with auto-answering capability, the local modem can be either an external or an internal modem. The next step is to establish communication between the two modems, possibly using a second computer temporarily with the remote modem. If both computers are running Windows 3.1, a convenient method to communicate between the two computers would be to use Terminal in the Accessories window. Terminal can write to a computer's serial port and will prove helpful in configuring the remote and local modems. However, any application software that has the ability to write to a computer's serial port can also be used.

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Remote Modem Setup

The remote modem needs to be set up to auto-answer after a specified number of rings. To determine how to do this, consult the technical reference manual for your modem. This application note was developed using the Hayes 2400 modem; therefore, the following settings can be used to configure this type of modem.

For the Hayes 2400 modem, the S-register, S0, must be set to a nonzero value to enable auto-answering. The default setting for the S0 register is zero, which disables auto-answering. The S0 register must be set to S0=1, S0=2, or S0=3 for the modem to auto answer after one, two, or three rings, respectively. When the S0 register is changed, the changes are made to the active profile, which contains the settings that the modem uses during operation. The active profile is loaded from nonvolatile memory when the unit is powered up. Therefore, when changes are made to the active profile, it is essential to save those changes to memory. This memory is called stored profiles, and for the Hayes 2400 modem these profiles are called stored profile 0 and stored profile 1. It is equally important to make sure that the correct stored profile is loaded when the unit is powered up. This ensures that the remote modem will power up as an auto-answering modem. The following is an example of the active and stored profiles:

ACTIVE PROFILE:

```
B1 B16 E1 L1 M1 N1 Q0 T V0 W0 X4 Y0 &C1 &D0 &G0 &J0 &K3 &Q5 &R0 &S0 &T4 &X0 &Y0
S00:002 S01:000 S02:043 S03:013 S04:010 S05:008 S06:002 S07:050 S08:002 S09:006
S10:014 S11:095 S12:050 S18:000 S25:005 S26:001 S36:007 S37:000 S38:020 S44:003
S46:002 S48:007 S49:008 S50:016
```

STORED PROFILE 0:

```
B1 B16 E1 L1 M1 N1 Q0 T V1 W0 X4 Y0 &C1 &D0 &G0 &J0 &K3 &Q5 &R0 &S0 &T4 &X0
S00:002 S02:043 S06:002 S07:050 S08:002 S09:006 S10:014 S11:095 S12:050 S18:000
S25:005 S26:001 S36:007 S37:000 S38:020 S44:003 S46:002 S48:007 S49:008 S50:016
```

STORED PROFILE 1:

```
B1 B16 E1 L2 M1 N1 P Q0 V1 W0 X4 Y0 &C1 &D0 &G0 &J0 &K3 &Q5 &R0 &S0 &T4 &X0
S00:000 S02:043 S06:002 S07:050 S08:002 S09:006 S10:014 S11:095 S12:050 S18:000
S25:005 S26:001 S36:007 S37:000 S38:020 S44:003 S46:002 S48:007 S49:008 S50:016
```

With the modem AT commands, the S-registers can be set using the Terminal program in the Accessories program group found in Windows 3.1, or any other application program that can communicate with a computer's serial port. Once these modem settings have been set and saved on the modem, the use of a computer with the remote modem is no longer necessary. The following is a summary of AT commands used to setup the remote modem:

AT S0=1	* Set modem to auto-answer after 1 ring *
AT S0=2	* Set modem to auto-answer after 2 ring *
AT S0=3	* Set modem to auto-answer after 3 ring *
AT&V	* View Configuration Profiles, Active and Stored *
AT&W0	* Store the Active Profile into Stored Profile 0 *
AT&W1	* Store the Active Profile into Stored Profile 1 *
AT&Y0	* Select Stored Profile 0 on power-up *
AT&Y1	* Select Stored Profile 1 on power-up *

Using the GPIB-232CT-A in S-Mode

To implement a remote GPIB control application, the GPIB-232CT-A can be configured to operate in S-Mode. In this mode, the GPIB-232CT-A functions as a GPIB system controller, performing the various tasks required in managing a GPIB network of instruments. These tasks include addressing Talkers and Listeners on the bus, managing information transfer across the bus and managing requests for service by various devices on the GPIB. The S-Mode was designed into the GPIB-232CT-A so users could remotely control GPIB instruments using the computer serial port. Now we are adding modems and telecommunications links to remove the 50 ft. distance limit of the RS-232 standard.

The following table summarizes all of the S-Mode programming functions that can be used to control the GPIB-232CT-A. Similar to the NI-488.2 software routines and functions, the S-Mode programming set provides functions for I/O, High-Level Bus Management, Low-Level Bus Management, GPIB Initialization, Serial Polling, Parallel Polling and Serial Port Management. For a more detailed discussion of each of the functions listed below, consult the GPIB-232CT-A User Manual.

Table 1. GPIB-232CT-A Functions in S-Mode

cac mode	Become Active Controller
caddr address	Change the IEEE 488 address of the GPIB-232CT-A
clr address list	Clear specified device(s)
cmd count commands	Send IEEE 488 commands
conf option value	Read/change configuration
echo on/off	Echo characters received from serial port
eos modes, eoschar	Change or disable GPIB end-of-string termination mode
eot on/off	Enable or disable END termination message on GPIB write operations
gts mode	Go from Active Controller to Standby
id	Identify system
ist set/clear	Set or clear individual status bit for use in GPIB-232CT-A response to Parallel Polls
lines	Determine state of GPIB control lines
ln address list	Check for listening devices
loc address list	Go to Local
onl /off	Place the GPIB-232CT-A online/offline
pct address	Pass Control
ppc values	Parallel Poll Configure
ppu address list	Parallel Poll Unconfigure
rd count, address	Read data
rpp	Conduct (request) a Parallel Poll
rsc on/off	Request System Control
rsp address list	Conduct (request) a serial poll
rsv status byte	Request service and/or set or change the serial poll status byte
sic time	Send interface clear
spign on/off	Ignore serial port errors
sre on/off	Set remote enable
stat modes	Return GPIB-232CT-A status
tmo values	Change or disable time limits
trg address list	Trigger selected device(s)
wait mask	Wait for selected event(s)
wrt count, address list data	Write data
xon modes	Change serial port XON/XOFF protocol

The advantage of using S-Mode programming to control the GPIB-232CT-A is that these functions do not require the presence of the NI-488.2 driver software. The functions are designed to be sent directly to the GPIB-232CT-A via a serial link, eliminating the additional overhead of the NI-488.2 software.

Establishing Communications with Your Remote GPIB Controller

The following section outlines the steps required to establish a communications link with a remote test site, interface with the GPIB-232CT-A, and then terminate the communications link with the remote test site once all GPIB activities have been completed. The following subsections sequentially illustrate each step in the interfacing process using LabWindows/CVI. A complete listing of the source code appears in Appendix A.

Opening Serial Port Communications

The following example code opens access to serial port 2. The serial port is configured to operate at 2400 baud, no parity, eight data bits, one stop bit and an input/output queue size of 512 bytes. The communication mode is also set up for Hardware Handshaking (CTS). CheckCOMportError uses the variable ComError to check for serial port error conditions.

```
ComError = OpenComConfig (2, "COM2", 2400, 0, 8, 1, 512, 512);
CheckCOMportError(ComError);

ComError = SetCTSMode (2, 1); /* Require Clear To Send signal for handshaking data*/
CheckCOMportError(ComError);
```

Connecting to the Remote Modem

The following example code illustrates how to configure a local modem via the serial port. Once the configuration has been sent, the next programming instruction establishes a communications link with the remote site by dialing the remote modem. Each modem is different so you must determine the correct configuration string for the modem that you are using.

```
BytesWritten = ComWrt (2, "ATQ0V1E1S0=0\r\n", 14); /* Send Configuration String*/
Delay (2);
BytesWritten =ComWrt (2, "ATDT97945775\r\n", 14); /* Dial Remote Modem*/
```

Once the connection has been established, the local modem returns a connection response string in the serial port input buffer. We use this string to verify that the connection has been made in the desired configuration. The modem itself is automatically placed into Data Transfer Mode; by writing directly to the serial port, you can send information over the modem link to your remote GPIB-232CT-A.

```
while (InQLen < 4) { /* Wait for Response String*/
    InQLen = GetInQLen (2); /*Check input queue for data*/
}

BytesRead = ComRd (2, databuf, 80); /*Read Response String*/
if (strcmp(databuf, "\r\nCONNECT 2400", 14) == 0) /*Check for Valid Connection*/
    printf("Connection Successful!\n");

else { printf("No Carrier: Connect Unsuccessful!\n");
    exit (0);
}
```

Remote Interfacing with the GPIB-232CT-A

The following code illustrates how to initialize the GPIB-232CT-A as System Controller. Users can also use the tmo, eot, and eos functions to modify time-out, termination method, and the end of string features, respectively. The code below assumes the default settings of 10 second time-out, EOI termination, and no EOS byte. Each line of code that executes GPIB operations is followed by the function, CheckGPIBError. It is important to verify that no GPIB errors have occurred after executing a GPIB operation. See the Application code in Appendix A for a listing of this function.

```
BytesWritten = ComWrt (2, "onl 1\r", 6); /* Write six byte string to COM2: CT-A Online*/
CheckGPIBError();

BytesWritten = ComWrt (2, "sic\r", 4); /* Write four byte string to COM2: Send IFC*/
CheckGPIBError();
```

The following code illustrates how to query a device on the GPIB for its identification. The “*IDN?” string is used to prompt a IEEE 488.2 instrument to send its identification string on the next read from that device. The device resides at address 8.

```
BytesWritten = ComWrt (2, "wrt 8\n*IDN?\r\n", 13); /*Query device for identification*/
CheckGPIBError();                               /*Device resides at address 8*/

BytesWritten = ComWrt (2, "rd #70 8\r\n", 10);    /*Read back identification from device*/
BytesRead = ComRdTerm (2, databuf, 100, 13); /*Read identification from COM2 Buffer*/
CheckGPIBError();
```

The following code illustrates how to conduct a serial poll by manually polling every device on the bus. In this case the device at address 8 asserts SRQ when data becomes available. The program returns status information, using the ReadAllStatus function, when SRQ is detected. All status information is converted from ASCII to Hex and a Mask is used to check if the SRQI bit of GPIB status has been set. Once SRQI has been detected, the serial poll byte is read back and available measurement data is retrieved from the instrument. See Appendix A for a listing of the ReadAllStatus function.

```
BytesWritten = ComWrt (2, "wait 4096\r", 10);    /*Wait for SRQ*/
while (InQLen < 4) {                             /*All Status returned when SRQ occurs*/
    InQLen = GetInQLen (2);                       /*Check COM2 Input Queue for status*/
}
ReadAllStatus();                                /*Read all status information*/
Scan (Status, "%s>%d", &hexStat);               /*Convert ASCII Status to Hex*/

if(hexStat & 0x1000) {                            /*Check for SRQ*/
    Delay(2);
    FlushInQ (2);                                /*Intialize variables*/
    FillBytes (spoll, 0, 5, 0);
    hexSpoll = 0;
    BytesWritten = ComWrt (2, "rsp 8\r", 6);       /*Read back Serial Poll Byte: Address 8*/
    BytesRead = ComRdTerm (2, spoll, 5, 13);      /*Read Serial Poll from COM2 Buffer*/
    Scan (spoll, "%s>%d", &hexSpoll);
    if (hexSpoll & 0x40) {
        BytesWritten = ComWrt (2, "rd #70 8\r\n", 9); /*Read data from device*/
        BytesRead = ComRdTerm (2, DCbuf, 70, 13); /*Read data from COM2 Buffer*/
    }
    Delay(2);
    FlushInQ (2);                                /*Intialize variables*/
    FillBytes (spoll, 0, 5, 0);
    hexSpoll = 0;
    BytesWritten = ComWrt (2, "rsp 2\r", 6);       /*Read back Serial Poll Byte: Address 2*/
    BytesRead = ComRdTerm (2, spoll, 5, 13);      /*Read Serial Poll from COM2 Buffer*/
    Scan (spoll, "%s>%d", &hexSpoll);
    if (hexSpoll & 0x40) {
        BytesWritten = ComWrt (2, "rd #70 2\r\n", 9); /*Read data from device*/
        BytesRead = ComRdTerm (2, DCbuf, 70, 13); /*Read data from COM2 Buffer*/
    }
}
}
```

Disconnecting from Remote GPIB Controller

Once data collection from the remote GPIB system has been completed, the GPIB Controller should be taken off-line.

```
BytesWritten = ComWrt (2, "onl 0\r", 6);    /* Place the GPIB-232CT-A off-line*/  
CheckGPIBError();
```

Send the escape sequence to place the local modem into Command Mode. Then send the hang up command string.

```
BytesWritten = ComWrt (2, "+++", 3); /* Place local modem in Command Mode*/  
Delay(2);  
BytesWritten = ComWrt (2, "ATH\r\n", 5); /* Hang Up*/
```

To complete your application program, close access to the computer serial port.

```
ComError = CloseCom (2);  
CheckCOMportError(ComError);
```

General Programming Considerations

Delays are used from time to time to slow down portions of the code in order to allow ample time for information to be processed through the serial port. You will need to experiment to determine where these delays might be necessary. In addition, flushing input and output queues prior to sending and receiving data, checking the input queue prior to reading data from the serial port, and checking for GPIB and serial port errors is highly recommended.

Error checking is important. However, an even more basic requirement is to clearly understand the syntax involved in using the S-Mode functions. For example, whenever a command is sent to the GPIB-232CT-A, a specific type of termination character (Generally a linefeed or a carriage return) must be appended to the end of that command. This allows the GPIB-232CT-A to terminate correctly and recognize that a command has been sent to it; and so, in general, be very careful to adhere to the syntax rules outlined for each S-Mode programming function. The LabWindows/CVI example appearing in Appendix A illustrates the use of these termination characters when using the S-Mode programming functions to interface with the GPIB-232CT-A.

Many users may choose to use programming languages other than LabWindows/CVI. In general, the entire interfacing process is streamlined somewhat if the user chooses a language that has standardized functions for easy access to your serial port. QuickBasic, HP Basic, Visual Basic, and the LabWindows programming environments have this particular feature. Otherwise, the user must access the UART, that manages the computer serial ports, on a register level in order to read, write, and check input and output queue lengths for a particular serial port. To assist in porting the LabWindows/CVI program in Appendix A to another language, Appendix B describes the functions performed.

APPENDIX A

LabWindows/CVI Example Program

```
/******INCLUDES******/
#include <formatio.h>
#include <gpib.h>
#include <userint.h>
#include <ansi_c.h>
#include <utility.h>
#include <rs232.h>

/******FUNCTION PROTOTYPES******/
void CheckCOMportError (int);
void ReadAllStatus(void);
void CheckGPIBError(void);

/******GLOBALS******/
static int ComError;
static int BytesWritten;
static int BytesRead;
static int Flag;
static int handle;
static int hexStat;
static int hexSpoll;
static int InQLen;
static int GPIBErrCode;

charStatus[10];
charGPIBerr[5];
charSPerr[5];
charcount[5];
char databuf[100];
char DCbuf[100];
char Timeout[5];
char spoll[5];

/******MAIN******/
main(){

    /******OPEN & CONFIGURE COM2: HW HANDSHAKE******/
    ComError = OpenComConfig (2, "COM2", 2400, 0, 8, 1, 512, 512);
    CheckCOMportError(ComError);

    ComError = SetCTSMMode (2, 1);
    CheckCOMportError(ComError);

    /******CONNECT TO REMOTE MODEM******/
    BytesWritten = ComWrt (2, "ATQ0V1E1S0=0\r\n", 14);
    Delay (2);
    BytesWritten = ComWrt (2, "ATDT97945775\r\n", 14);
    Delay(2);
    FlushInQ (2);
    InQLen = 0;

    while (InQLen < 14) {
        InQLen = GetInQLen (2);
    }
}
```

```

BytesRead = ComRd (2, databuf, 80);
if (strncmp(databuf, "\r\nCONNECT 2400", 14) == 0)
    printf("Connection Succesful!\n");

else {    printf("No Carrier: Connect Unsuccessful!\n");
        exit (0);
        }
Delay (2);
FlushInQ (2);

/*****GPIB-232CT-A INTERFACING*****/
/* Command: *IDN? returns instrument ID from 488.2 Instrument. */
/* Command: *SRE 16 enables the Service Request Enable register */
/*           of a 488.2 instrument. Instrument will assert SRQ */
/*           when data ready. */
/* Command: VAL1? instructs our device to return DC voltage. */
/*****/

BytesWritten = ComWrt (2, "onl 1\r", 6);
CheckGPIBError();

BytesWritten = ComWrt (2, "sic\r", 4);
CheckGPIBError();

BytesWritten = ComWrt (2, "wrt 8\n*IDN?\r\n", 13);
CheckGPIBError();

BytesWritten = ComWrt (2, "rd #70 8\r\n", 10);
BytesRead = ComRdTerm (2, databuf, 100, 13);
CheckGPIBError();
printf("%s\n", databuf);

BytesWritten = ComWrt (2, "wrt 8\n*SRE 16\r\n", 15);
CheckGPIBError();

BytesWritten = ComWrt (2, "wrt 8\nVAL1?\r\n", 13);
CheckGPIBError();

Delay (2);
FlushInQ (2);
InQLen = 0;

BytesWritten = ComWrt (2, "wait 4096\r", 10);
while (InQLen < 4) {
    InQLen = GetInQLen (2);
}
ReadAllStatus();
Scan (Status, "%s>%d", &hexStat);

if(hexStat & 0x1000) {
    Delay(2);
    FlushInQ (2);
    FillBytes (spoll, 0, 5, 0);
    hexSpoll = 0;
    BytesWritten = ComWrt (2, "rsp 8\r", 6);
    BytesRead = ComRdTerm (2, spoll, 5, 13);
    Scan (spoll, "%s>%d", &hexSpoll);
    if (hexSpoll & 0x40) {

```



```

        BytesWritten = ComWrt (2, "rd #70 8\r\n", 10);
        BytesRead = ComRdTerm (2, DCbuf, 70, 13);
    }
    Delay(2);
    FlushInQ (2);
    FillBytes (spoll, 0, 5, 0);
    hexSpoll = 0;
    BytesWritten = ComWrt (2, "rsp 2\r", 6);
    BytesRead = ComRdTerm (2, spoll, 5, 13);
    Scan (spoll, "%s>%d", &hexSpoll);
    if (hexSpoll & 0x40) {
        BytesWritten = ComWrt (2, "rd #70 2\r\n", 9);
        BytesRead = ComRdTerm (2, DCbuf, 70, 13);
    }
}
/*****DISCONNECT FROM REMOTE MODEM*****/
BytesWritten = ComWrt (2, "onl 0\r", 6);
CheckGPIBError();

    FlushOutQ (2);
    BytesWritten = ComWrt (2, "+++", 3);
    Delay(2);
    BytesWritten = ComWrt (2, "ATH\r\n", 5);
    Delay(3);

/*****CLOSE COM2*****/
ComError = CloseCom (2);
CheckCOMportError(ComError);

}/**END MAIN**/

/*****FUNCTION DECLARATIONS*****/
/*****/
/* Function:      CheckCOMportError          */
/* Parameters:    int error value returned    */
/* Return Value:  NONE                       */
/* Description:   This function checks the com port
/* error code and returns the appropriate message.
/* Error codes are referenced in LWCVI user manual.
/*****/

void CheckCOMportError (int err_value) {
    if (err_value < 0) {
        MessagePopup ("Communications Error", "Com Port Error: Program Aborted.");
        exit (0);
    }
}

/*****/
/* Function:      ReadAllStatus              */
/* Parameters:    NONE                       */
/* Return Value:  NONE                       */
/* Description:   This function reads all status
/* information returned by "wait".
/*****/

void ReadAllStatus(void) {

```

```

FillBytes (Status, 0, 10, 0);
FillBytes (GPIBerr, 0, 5, 0);
FillBytes (SPerr, 0, 5, 0);
FillBytes (count, 0, 5, 0);

BytesRead = ComRdTerm (2, Status, 10, 13);
BytesRead = ComRdTerm (2, GPIBerr, 5, 13);
BytesRead = ComRdTerm (2, SPerr, 5, 13);
BytesRead = ComRdTerm (2, count, 5, 13);
}

/*****
/* Function:      CheckGPIBError          */
/* Parameters:    NONE                    */
/* Return Value:  NONE                    */
/* Description:   This function reads all status
/* information returned by "stat". If an error
/* condition exists, display error code and exit prgm.
*****/

void CheckGPIBError (void) {

    Delay (2);
    FlushInQ (2);

    BytesWritten = ComWrt (2, "stat n\r", 7);
    while (InQLen < 4) {
        InQLen = GetInQLen (2);
    }
    ReadAllStatus();
    Scan (Status, "%s>%d", &hexStat);
    Scan (GPIBerr, "%s>%d", &GPIBErrCode);
    if (hexStat < 0) {
        printf("GPIB Error: GPIB error code = %d\n", GPIBErrCode);
        exit (0);
    }
}

```

APPENDIX B

Description of the LabWindows/CVI Functions Used in Appendix A

Each of the RS-232 functions used in the LabWindows/CVI program in Appendix A is described. This information outlines the tasks accomplished by each function so that users can translate LabWindows/CVI calls to other programming languages.

OpenComConfig

This function opens access to a COM port in the desired configuration. Parameters include the COM port number and its mnemonic, baud rate, parity, data bits, and stop bits, as well as the ability to specify the size of software buffers that function as input and output queues for transmitting and receiving data. It returns an error code that can be found in the LabWindows Standard Libraries reference manual.

SetCTSMode

With this function the user can enable Hardware Handshaking. In general, for Hardware Handshaking to work, the serial devices with which you are interfacing must follow a compatible handshaking protocol and the serial cables being used must include the lines to support that handshaking protocol. We enable the use of the Clear To Send (CTS) and the Request To Send (RTS) handshaking lines using SetCTSMode. It returns an error code that can be found in the LabWindows Standard Libraries reference manual.

ComWrt

This function places a specified number of bytes, contained in a character buffer, into the output queue of a specified serial port. It returns the actual number of bytes that were placed in the output queue.

ComRd

This function reads a specified number of bytes from the input queue of a specified port and stores the information in a character buffer. It returns an integer value indicating the number of bytes that were actually read.

FlushInQ/FlushOutQ

Removes all characters from the Input/Output Queue of a specified port.

GetInQLen

This function returns the number of characters in the input queue of the specified port.

CloseCom

Closes a specified COM port and frees the allocated memory buffers for the input and output queues.